



Alternative Management of Liquid Swine Manure: Separation of solids and nutrients into value- added products

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Florence, South Carolina**

CONFINED SWINE PRODUCTION

- Industrial production of swine generates large amounts of waste
- Most farms use anaerobic lagoon and sprayfield technology
- Nitrogen and phosphorus exceed crop area available for disposal
- Also problems of odor and ammonia emissions

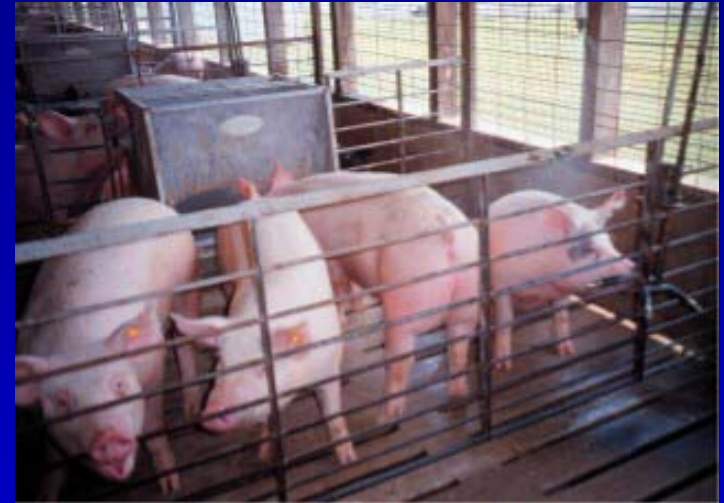


Phosphorus budget for Duplin Co, NC

- There is enough pastureland to apply 370,000 lb of P/year without building soil P
- vs. 16,934,000 lb of recoverable manure P available for application each year
- When crop uptake and pastureland are combined, there is a current annual excess of 15,647,000 lb of P due to animal production
- Thus, P needs to be removed from the farm and transported to other areas

Nutrients in swine manure in North Carolina

- 162 million lb of Nitrogen
- 54 million lb of Phosphorus
- Can provide all fertilizer needs for North Carolina's six largest agricultural counties
- Transport in liquid form is not feasible



BENEFITS OF SOLIDS-LIQUID SEPARATION

- Removes odor generation compounds and organic nutrients
- Allows movement of N and P to nutrient deficient areas
- Opens new alternatives for swine waste management:
 - Economic aeration treatment of liquid – ammonia removal
 - Extraction of soluble phosphates
 - Processing of solids for value-added products
 - Concentration strategies for biogas production

Smithfield Foods /Premium Standard agreement with Attorney General of North Carolina. 2000

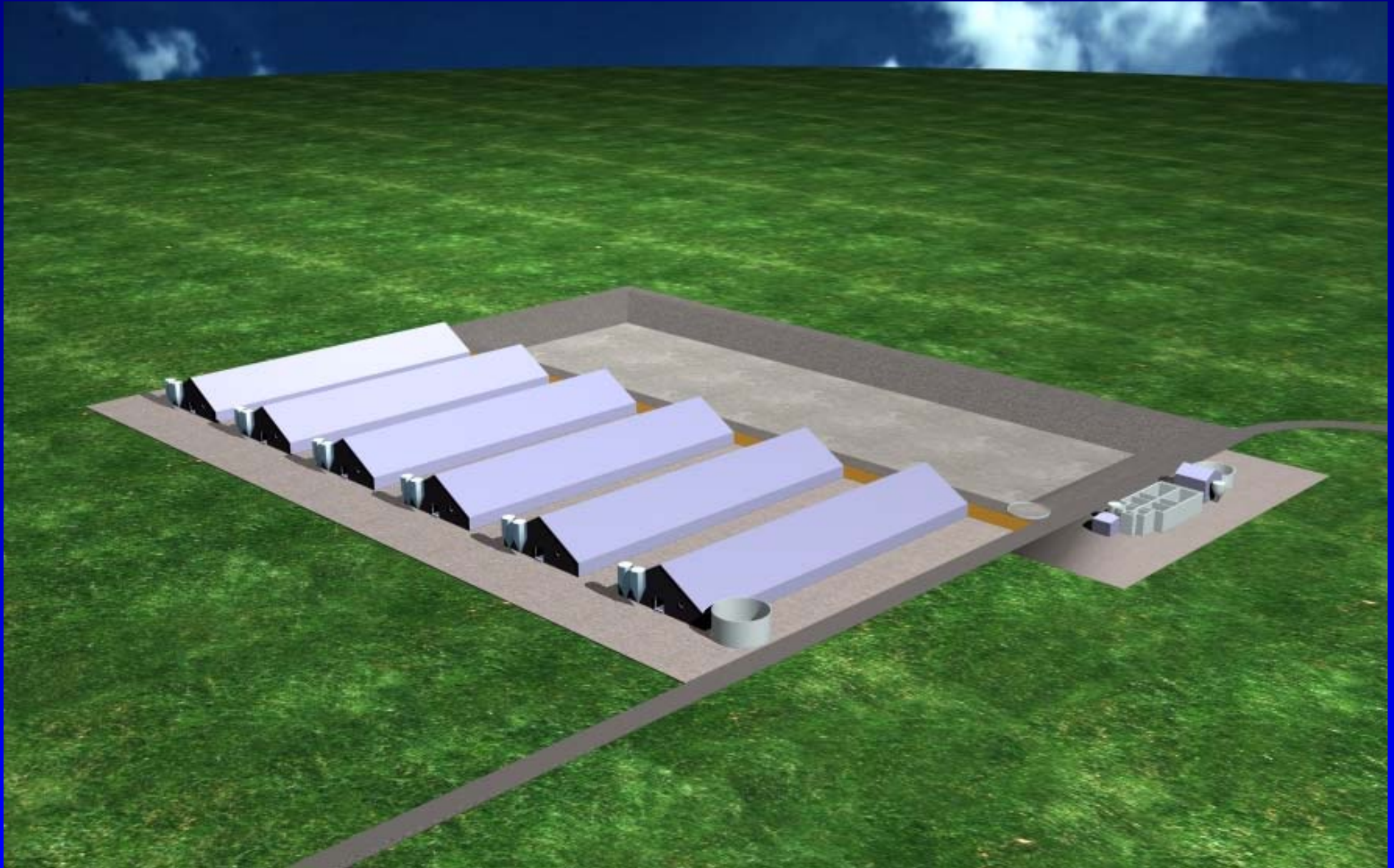
- Full-Scale demonstration of Environmental Superior Technologies to replace current hog lagoon-sprayfield system
- Competitive funding process
- Environmental performance standards (II.C.1.5):
 - Eliminate discharge to surface and groundwater
 - Eliminate ammonia emissions
 - Eliminate odor emissions beyond farm boundaries
 - Eliminate pathogens
 - Eliminate nutrient contamination of soil and water.

Project: Treatment system for elimination of lagoons, reduced environmental impact and improved water quality

- Super Soil Systems USA (NC): Production of soilless growth media from solids
- Selco M.C. (Spain): Solids separation module
- Hitachi Plant Engineering and Construction Co. (Japan): Biological ammonia removal
- Mitsui & Co (Chicago): Marketing of environmentally friendly pork meat and solids by-products
- USDA-ARS Florence and NCSU Animal Waste Mgmt Program: Scientific and engineering support.

Smithfield Project : Environmental Superior Technology

Solids separation and wastewater treatment at Duplin Co.



Smithfield Project: Centralized plant to stabilize manure solids & market value added products Super Soil Systems USA, Clinton, NC



VALUE-ADDED PRODUCTS: Soilless Media



Economic Analysis

Processing of Solids into Soilless Media

Smithfield Project: Finishing operation with 4360 pigs in NC

1,302 ton manure/year; 60% moist.

compost use cotton gin trash & bark

media: 50% compost/50% enhancing materials

Annual cost

Composting equipment
and site preparation

\$12,135

Blending & bagging equipment/bldg

\$4,253

Rental value of land (0.8 ac)

\$51

Operational and media materials

\$115,971

Sale of soilless media
4795 cu yrd @ \$45/cu yrd

\$215,792

Earnings per finished pig

\$6.83

System without lagoon

- Processing of separated solids (generation of income)
- Treatment of liquid fraction
- High-efficiency separation required

CAN SOLIDS IN LIQUID SWINE MANURE BE SEPARATED ?

- Solids in swine manure mostly in fine particles
- Fine solids clog sand filter beds
- Screen and presses only remove 10-15% of total suspended solids and organic nutrients
- Higher separation efficiencies possible with chemical treatment

SEPARATION EFFICIENCIES WITH SCREEN (1/32")

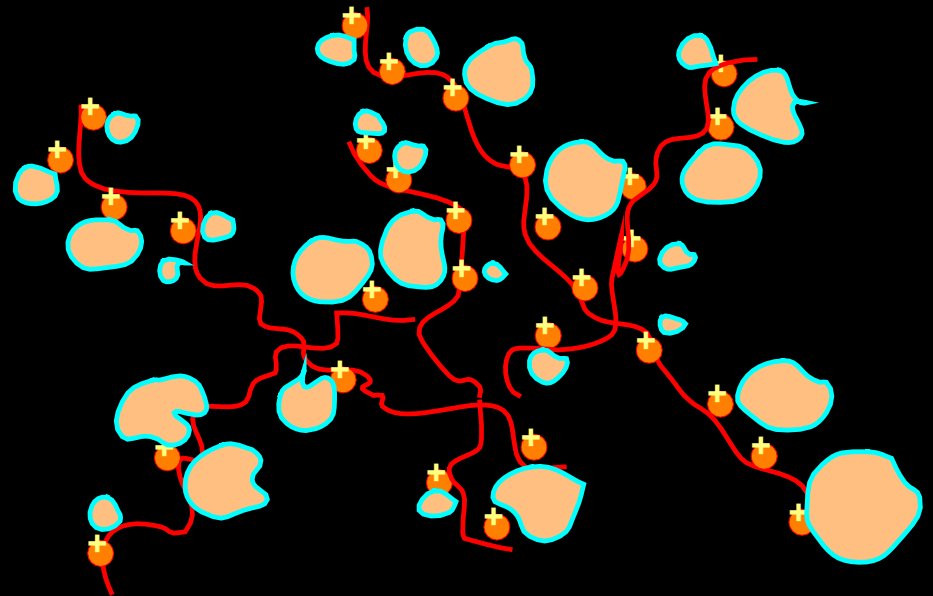


	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4	TRIAL 5	Average
TSS (%)	13	16	19	10	19	15.4
COD (%)	10	3	13	1	13	8
ORGANIC N (%)	13	8	14	18	13	13.2
ORGANIC P (%)	7	5	14	13	14	10.6

POLYACRYLAMIDE POLYMER (PAM)

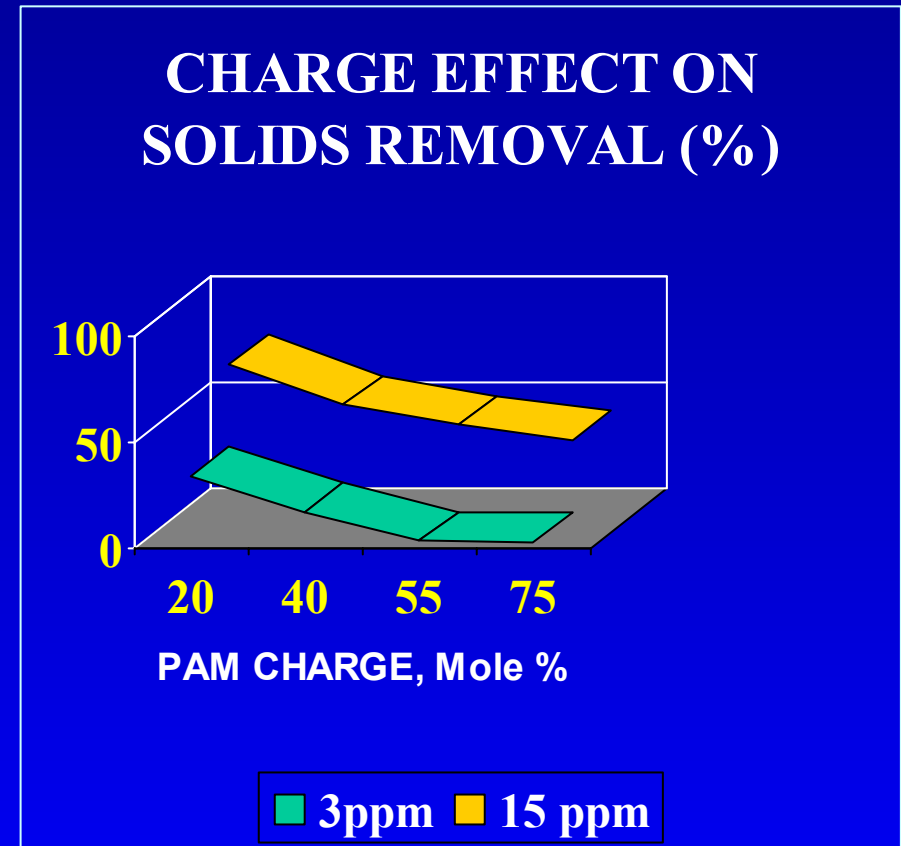
- Water soluble polymer, high molecular weight
- Applications: municipal, food processing, soil erosion, animal waste
- Absorb and bridge colloidal suspended particles into flocs
- Effective at low dosage

PAM Flocculation

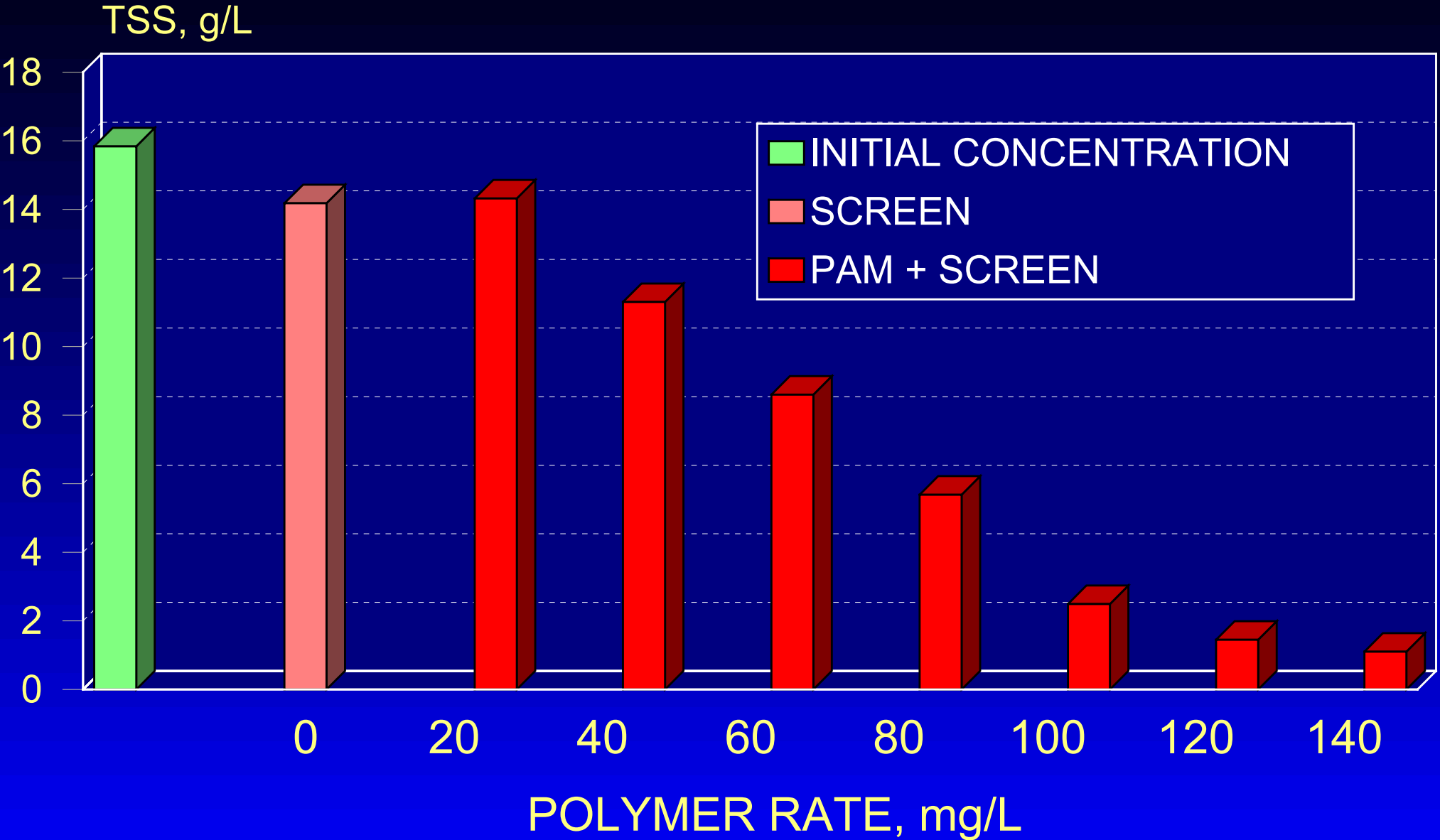


POLYACRYLAMIDE POLYMER (PAM)

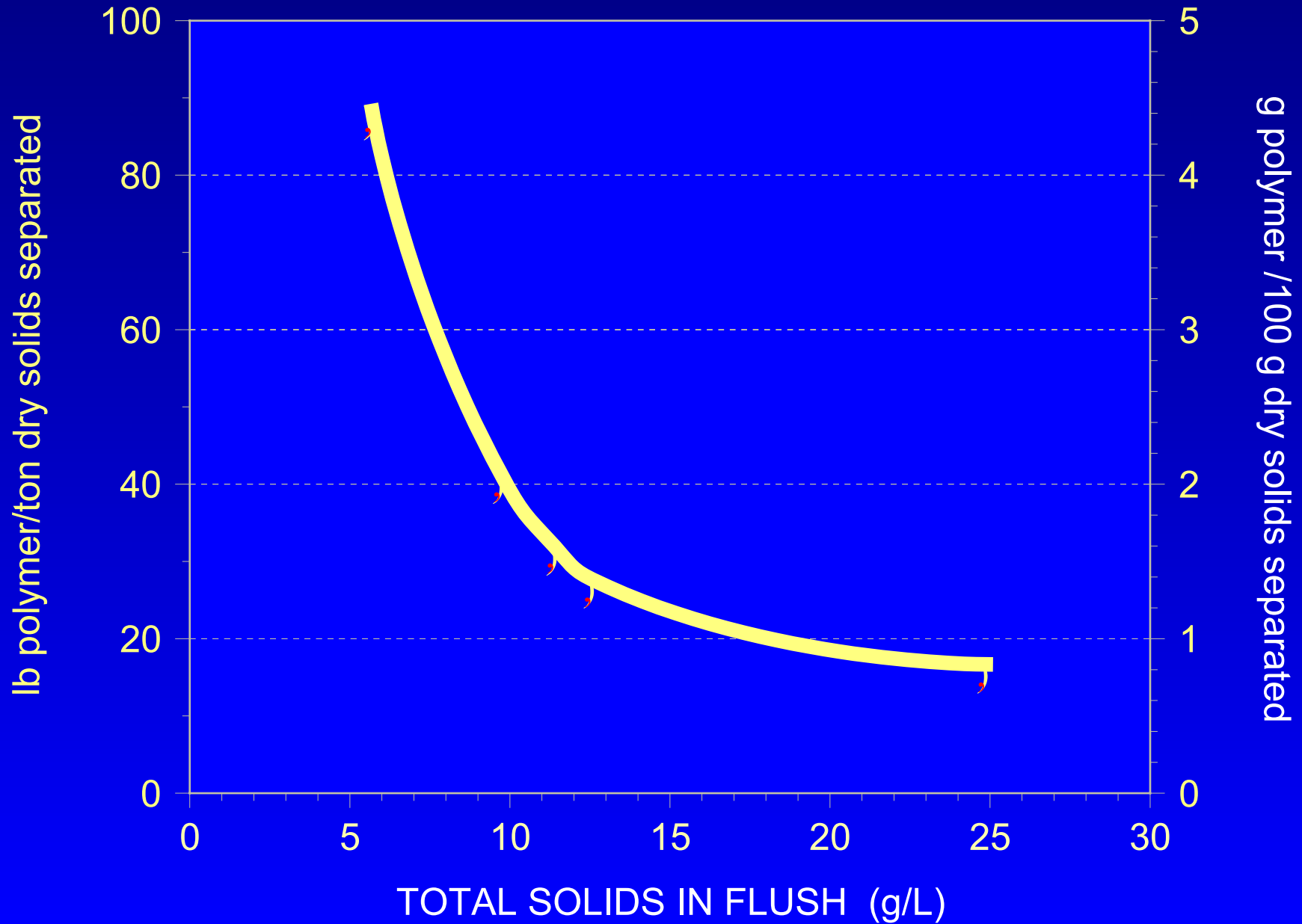
- More than 50 formulations available
- Cationic, Anionic, neutral
- Best for animal waste are cationic PAMs with low charge density



SOLIDS REMOVAL FROM FLUSHED SWINE MANURE USING PAM



Polymer usage rate: best results with higher strength wastewater

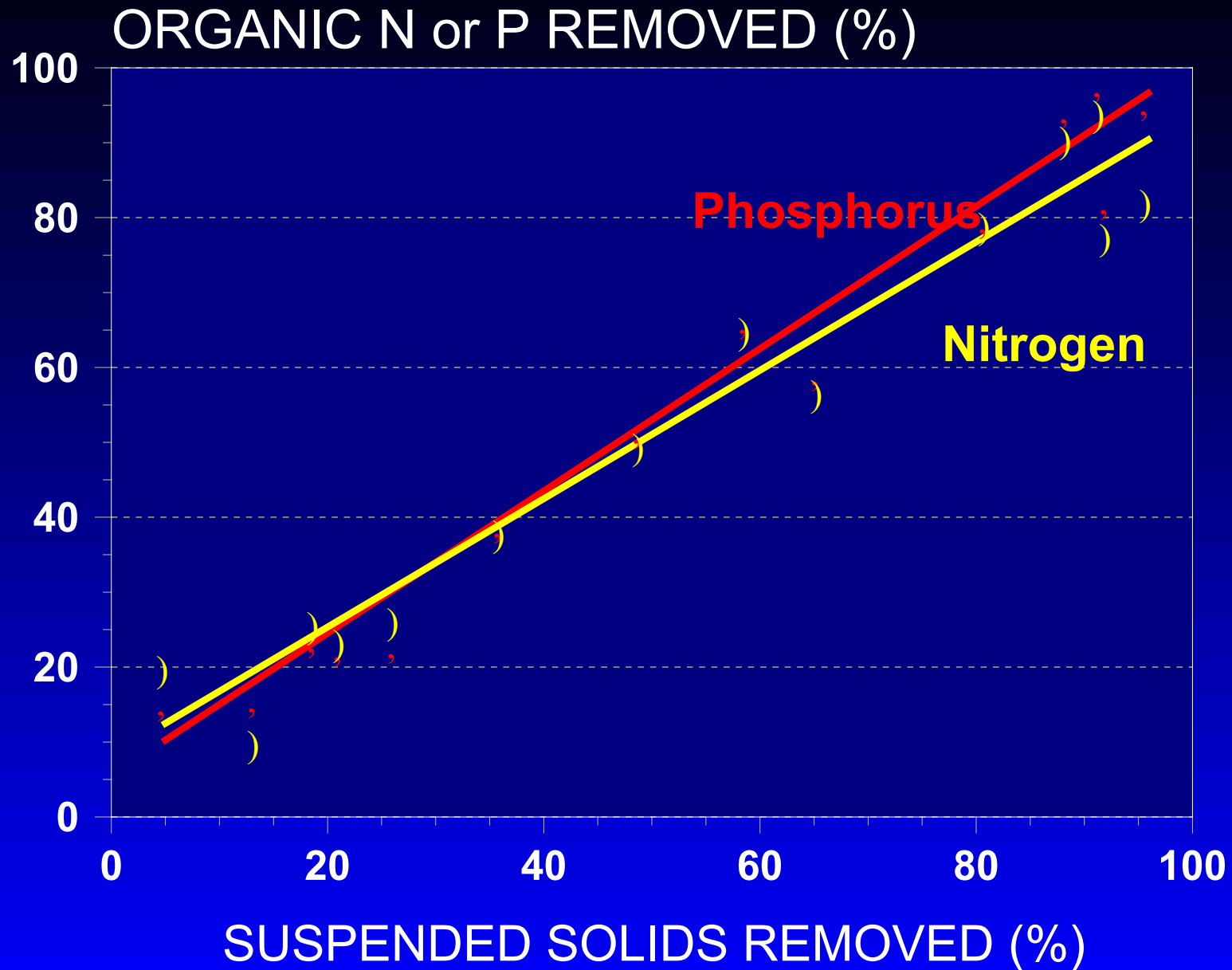


Chemical Cost

Based on

- Polymer usage rate = 0.9%
- Solids removal = 97%
- Polymer cost = \$1.80/lb
- Manure production = 5.05 lb dry/1000 lb /day
- Feeder to finish operation, 4400 head
- **Chemical cost = \$1.38 / finished pig**

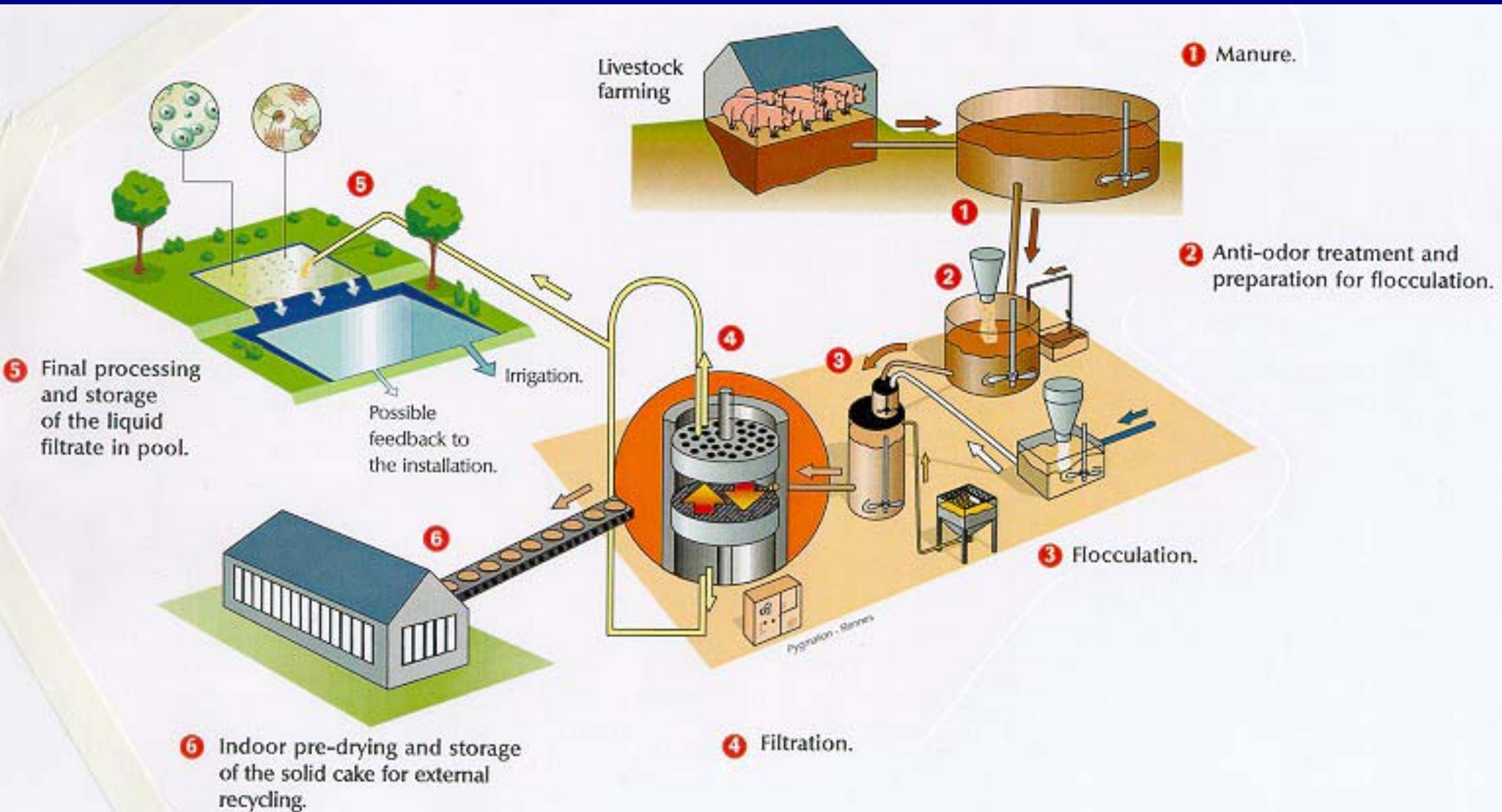
PAM treatment also removes nutrients from liquid manure



After flocculation with PAM, solids and liquid are separated and dewatered using:

- Filter presses – Ecoliz system
- Sand Filter beds – Deskins system
- Rotating screens – Selco system
- Belt filters – Bio/Resource system

Ecoliz Filter Press System in Brittany, France



Ecoliz Filter Press System in Brittany, France



Compression and filter chamber



Solid cake



Indoor storage of separated manure

Deskins sand filter drying beds: Construction of pilot unit at NCSU Animal Waste Center



Deskins system:

In-line polymer injection for flushed swine manure and pouring into sand filter bed

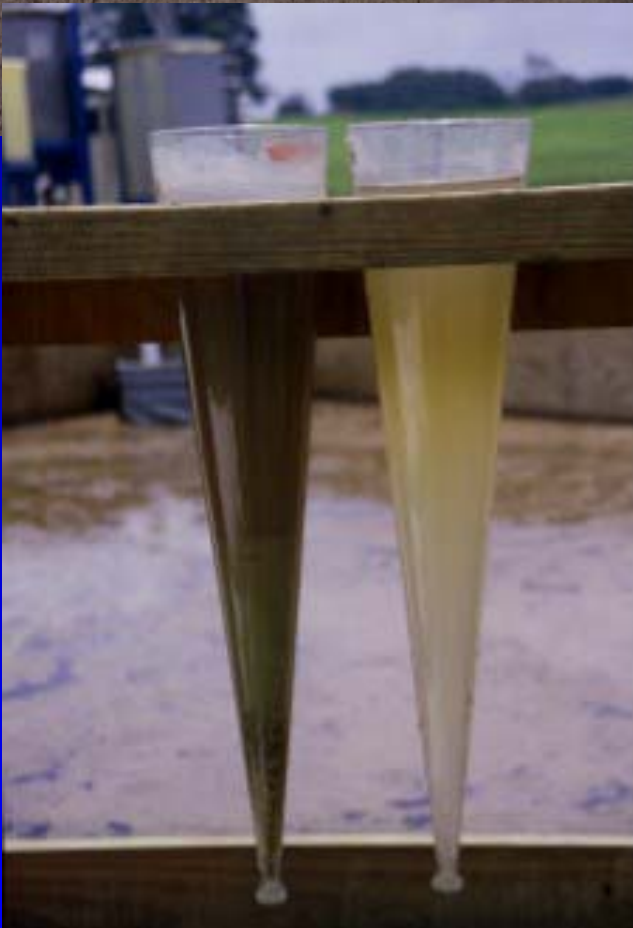


Deskins system

3 hours



3 days



PAM solids separation: Process Results

	INFLUENT (mg/L)	EFFLUENT (mg/L)	Efficiency (%)
Suspended Solids	7,410	135	98
Volatile Solids	6,110	107	98
COD	11,800	1,330	89
TKN	674	259	62
Organic N	443	41	91
TP	196	67	66
Organic P	162	12	93

SELCO Ecopurin Module in Modena, Italy:

PAM flocculation
and separation with
rotating screen



SELCO solids separation module: Rotating screen



SELCO system in Italy



Economic Analysis

PAM Liquid-solids separation

Smithfield Project: Finishing operation with 4360 pigs in NC

Solids removal = 97%

Wastewater = 33,000 gal/day

Interest rate = 8%

Annual cost

Selco separation module

\$16,356

**Building +
homogenization tank**

\$3,055

Polymer cost (9376 lb)

\$16,878

Energy costs (168 Kwh/d)

\$3,152

Cost per finished pig

\$3.23

Nutrient flow

The solids separation process capture nearly all the organic nutrients:

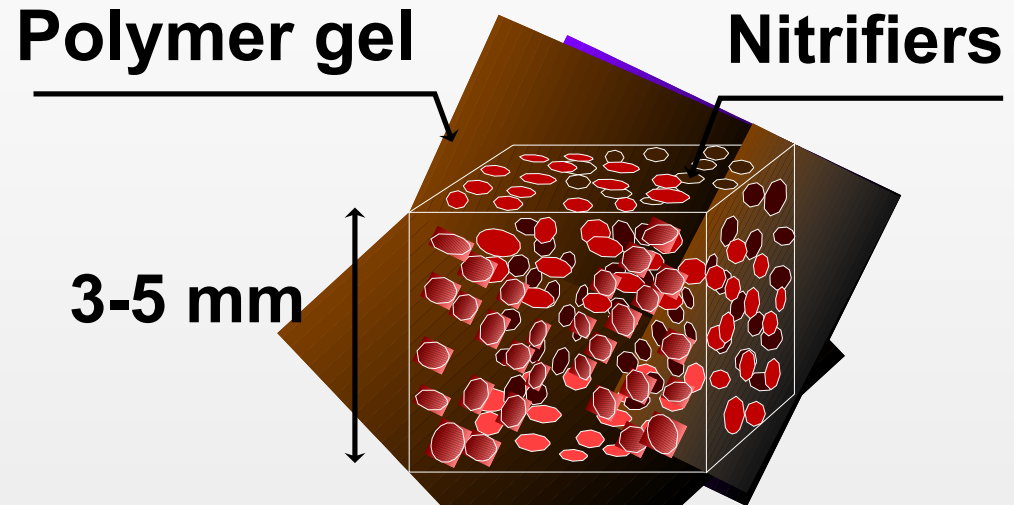
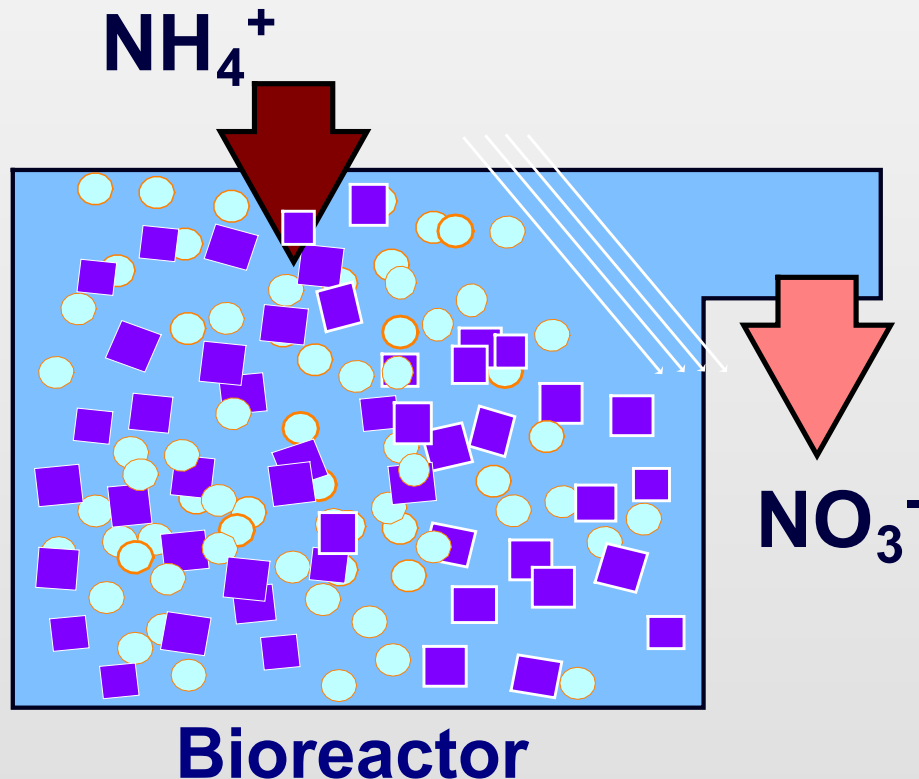
- 65 % of total N in fresh manure
- 85 % of total P in fresh manure

After separation, the liquid contains:

- 35 % of initial N, mostly ammonia
- 15 % of initial P, mostly phosphate

Nitrifying pellets:

Nitrifying bacteria is protected inside polymer pellets permeable to ammonia and oxygen



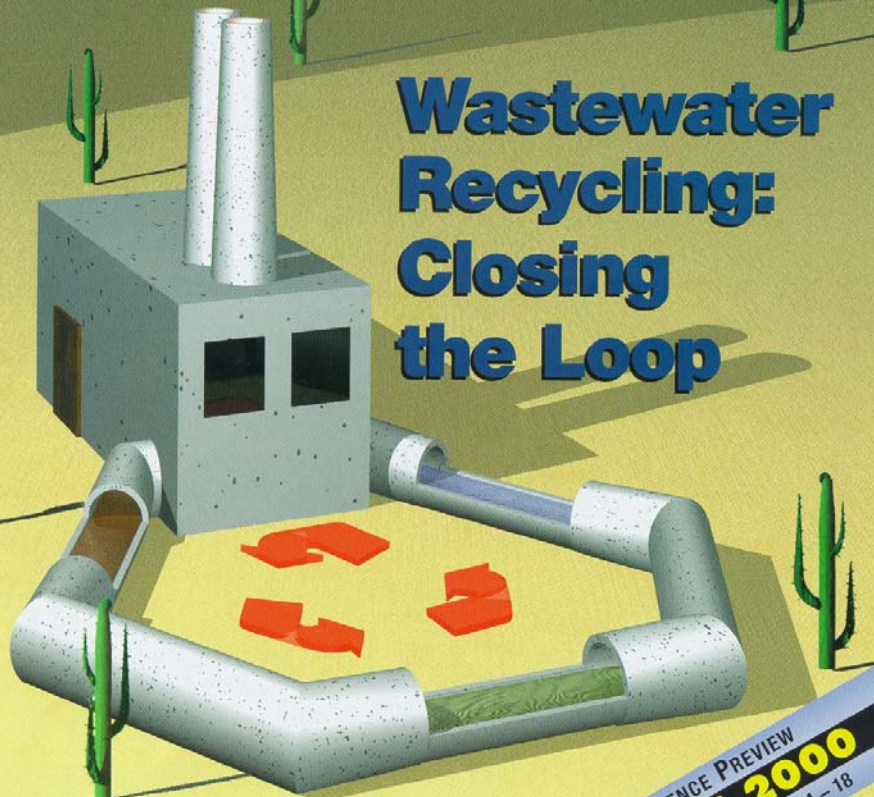
Wastewater is treated in a nitrification tank equipped with a screen to retain the pellets and an aeration system for fluidization

W E F Industrial Wastewater

WATER ENVIRONMENT FEDERATION

September/October 2000

Wastewater Recycling: Closing the Loop



- ◆ Nitrifying High-strength Wastewater
- ◆ Monitored Natural Attenuation

CONFERENCE PREVIEW
WEFTEC 2000
Anaheim, Calif. • Oct. 14 - 18

Nitrifying High-strength Wastewater

Japanese pellet technology effectively treats nitrogen in animal and other high-strength wastewater

By Matias B. Vanotti, Patrick G. Hunt, J. Mark Rice, and Frank J. Humenik

Tn Japan, municipal wastewater treatment plants use a state-of-the-art technology — microorganisms — to nitrify

ter treatment ion-denitrifica- t from munici- ng increasing wastewater n facilities. mal produc- tive and ing the nutri- is are desper-

retention time (HRT) — both of which are prohibitively expensive.

Aerobic treatment has been evaluated for treating animal wastewater, but in the absence of enriched nitrifying populations, aerobically treating high-ammonia animal wastewater may exacerbate environmental problems by stripping ammonia into the atmosphere.

Research indicates that immobilized pellet technology can nitrify animal lagoon wastewater at rates comparable to those found in Japan in municipal systems — rates that are three times higher than those achieved by conventional activated sludge treatment systems. In addition, the pellet technology is quick and relatively inexpensive.

Nitrifying Pellet Technology

The immobilization process provides an environment in which nitrifying microorganisms can perform optimally. Nitrifiers are entrapped in 3- to 5-mm pellets made of polymers that are permeable to the ammonia, oxygen, and carbon dioxide that the microorganisms need to thrive (see Figure 1, p. 31).

The pellets, typically made of polyethylene glycol and polyvinyl alcohol, are functional for more than 10 years. Wastewater is treated in a nitrification tank equipped with a whole-floor aeration system and a wedge-wire screen that retains the pellets, which comprise 7% to 15% of the reactor volume. According to Vanotti and Hunt (2000), immobilization technology also can

TRIAL WASTEWATER

September/October 2000

Industrial Wastewater

FEATURES

Recycling in the Desert

General Motors uses combined microfiltration system to reuse effluent and conserve water supplies at automotive assembly plants in arid regions
Lawrence V. Krzesowski, Gloria Garza, and Kameshwar Gupta

Growth Without Discharge

Implementing a wastewater recycling system eliminated one manufacturer's need to discharge to the local sewer system
Rick Marathe, Larry Peck, and Peter Gill

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Nitrifying High-strength Wastewater

Japanese pellet technology effectively treats nitrogen in animal and other high-strength wastewater
Matias B. Vanotti, Patrick G. Hunt, J. Mark Rice, and Frank J. Humenik

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Attenuation the Natural Way

A former wood-preserving site offers a case study for evaluating the potential of monitored natural attenuation
Miguel A. Sanchez, Larry M. Campbell, Frederick A. Brinkner, and Darryl Owens

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DEPARTMENTS

NEWS

U.S. EPA's Performance Track Offers Recognition, Incentives for Top Environmental Performance
Environmental Management Systems and Environmental Improvement: Do They Go Hand in Hand?

NEWS BRIEFS

TECH TALK

WEFTEC 2000 PREVIEW

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PROBLEM SOLVERS

Moving Bed Reactor System Helps Texas Refinery Meet Discharge Limits
Applying a Risk Based Business Approach to Process Sewer Assessment and Rehabilitation

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CALENDAR

On the Cover

Industries in arid regions increasingly are recycling wastewater to conserve scarce water supplies.

www.wef.org

Technical Innovation in Water Quality

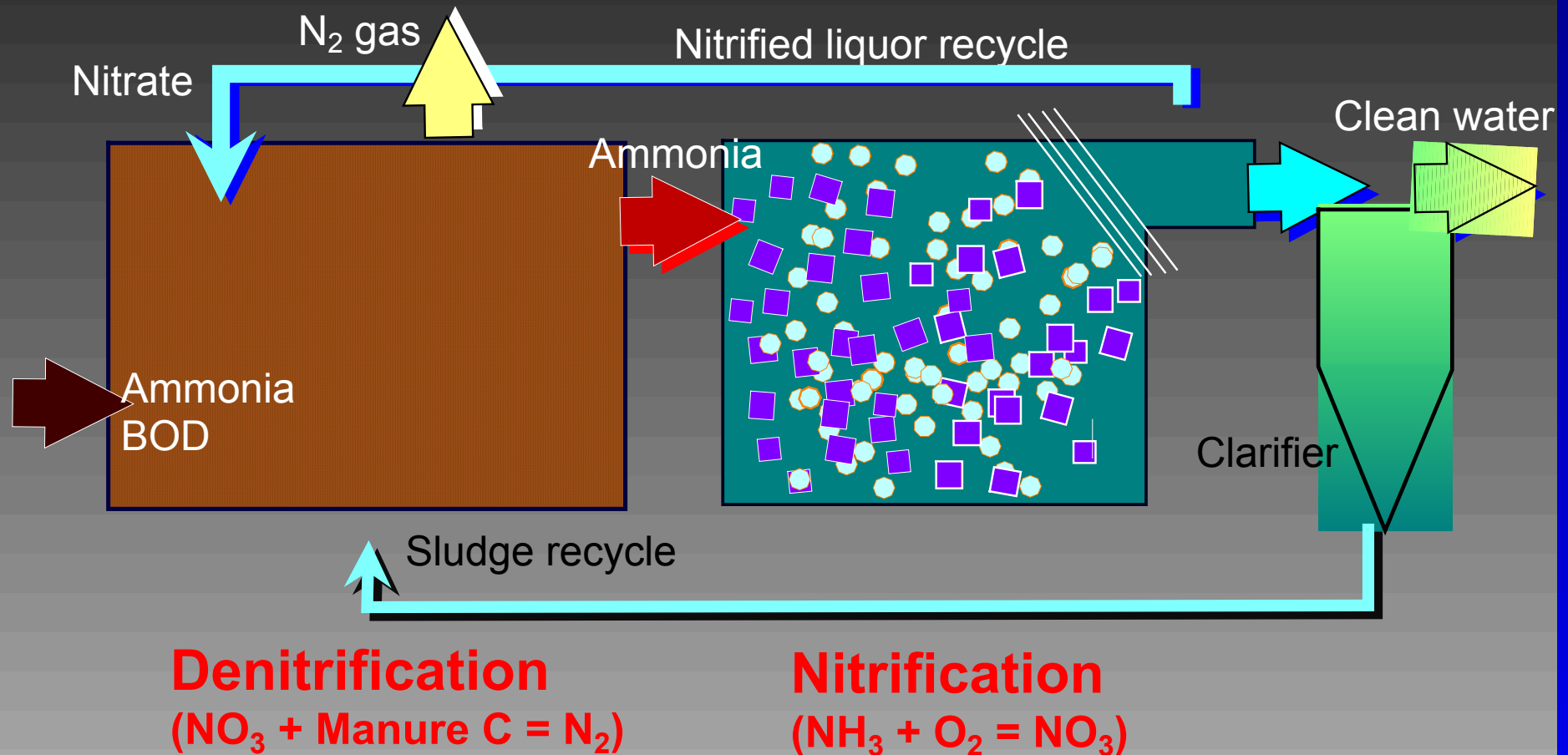


HIGH-AMMONIA NITRIFIERS

Batch treatment, influent ammonia 340 to 2600 ppm-N

Initial Ammonia Concentration mg N/L	Ammonia Removal Rate mg N/ L-reactor/day	Final Nitrate Concentration mg N/L	Efficiency %
344	991	348	100
860	924	855	99
1570	917	1525	97
2608	1013	2569	99

Biogreen system after solids-liquid separation using nitrifying pellets and denitrification for total N removal



Biogreen pilot unit at Raleigh: Biological Nitrogen Removal Module



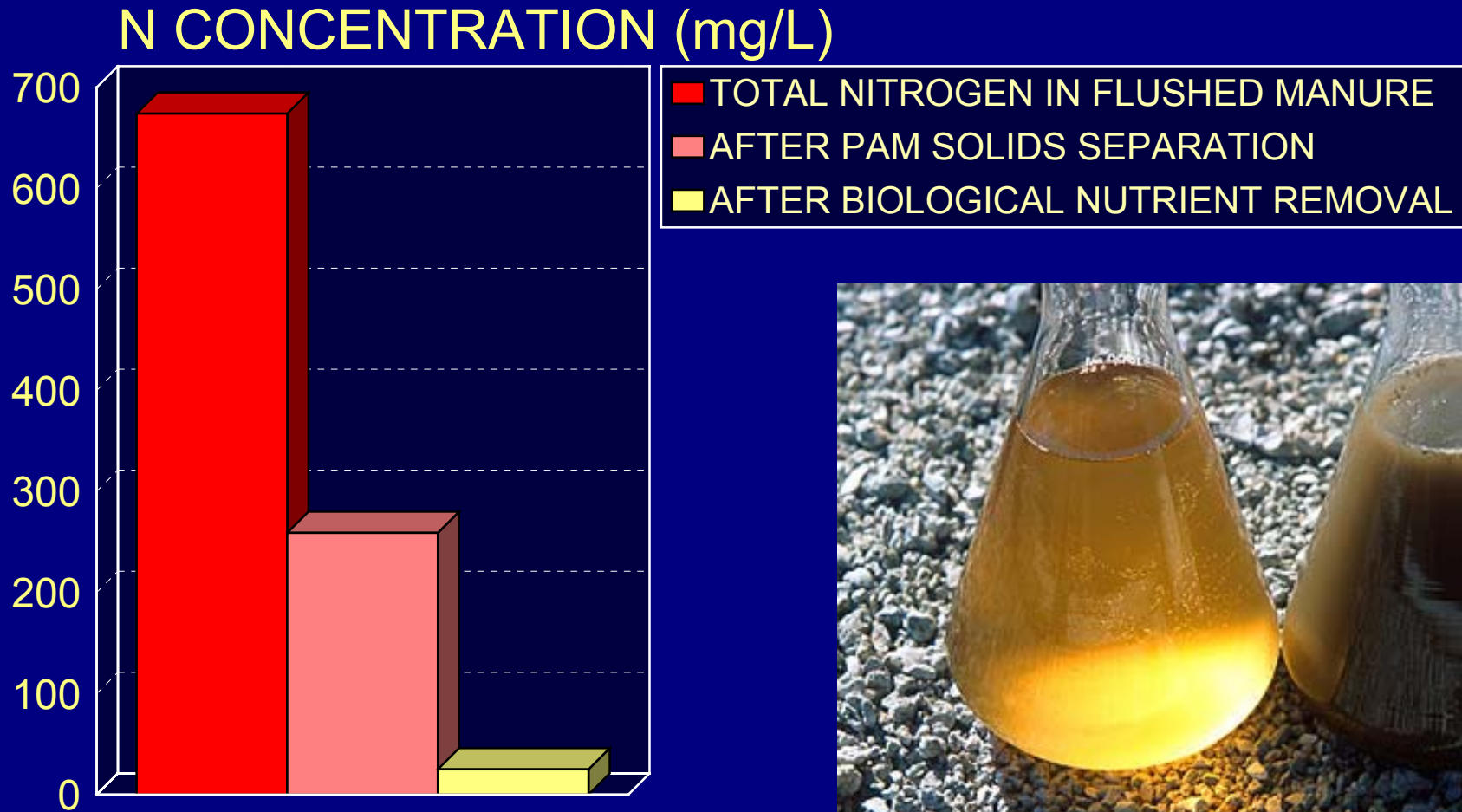
Pellets increase nitrifying bacteria concentration in tanks and ammonia treatment efficiency.

Ammonia Treatment: Biogreen Process Results

	INFLUENT (mg/L)	EFFLUENT (mg/L)
pH	7.7	7.9
Alkalinity	1,378	653
Suspended Solids	135	110
TKN	259	19
Ammonia	231	1
Nitrate	0	5

TREATMENT PERFORMANCE

SOLIDS SEPARATION + NITRIFICATION/DENITRIFICATION



Economic Analysis

Biological Ammonia Removal Treatment

Smithfield Project: Finishing operation with 4360 pigs in NC

Effluent Ammonia < 10 ppm

Wastewater = 33,000 gal/day

Water temperature = 10 °C

interest rate = 8%

Annual cost

**Reactor +
treated water tanks**

\$5,726

**Biogreen equipment +
nitrifying pellets**

\$15,298

Energy costs (395 Kwh/d)

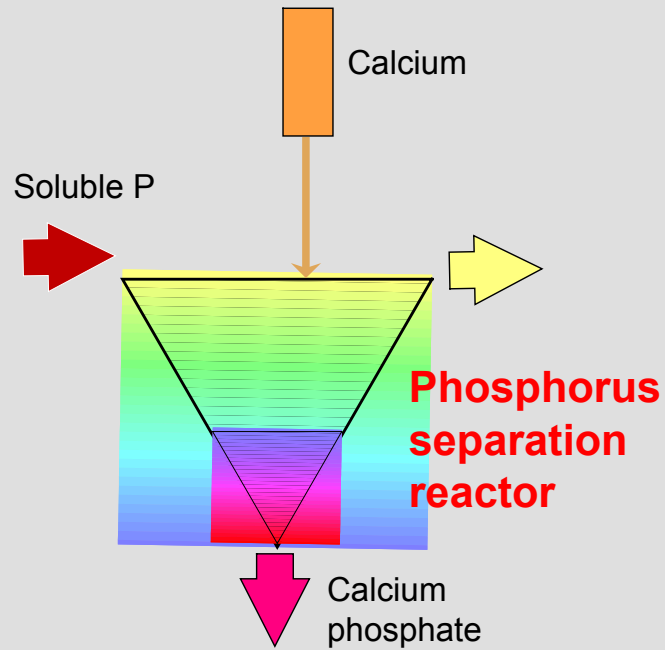
\$7,410

Cost per finished pig

\$2.33

-
- 2 Solids-liquid separation with PAM removes most organic nutrients and COD in liquid swine manure.
 - 2 Low carbon concentration important consideration for economical aeration and nitrification treatment.
 - 2 Immobilized technology provides quick and effective treatment of ammonia in animal wastewater.

Phosphorus Extraction and Dewatering/bagging



Phosphorus Removal: Process Results

Treatment	Applied Ca/Influent P	Total P	Effluent N/P	Product grade
	Molar ratio	mg/L	Conc. ratio	% P2O5
Influent		71.9	4.45	
Treated Effluent				
Level 1	0.82	25.5	11.9	17.5
Level 2	1.58	11.1	27.1	17.2
Level 3	2	3.3	90.6	16.1

N/P ratio of treated effluent can be adjusted for specific needs

Added Ca (Ca/P ratio)	Effluent P	N/P ratio
0	53.1	5.6
0.5	37.6	7.8
1	21.8	13.7
2	7.9	38
3	3.2	93.8

Prescribed use

■ Corn uptake needs

■ Bermudagrass needs

■ Sprayfield remediation

Economic Analysis

Phosphorus Extraction Treatment

Smithfield Project: Finishing operation with 4360 pigs in NC

P effluent < 5 ppm

Wastewater = 8,250 gal/day

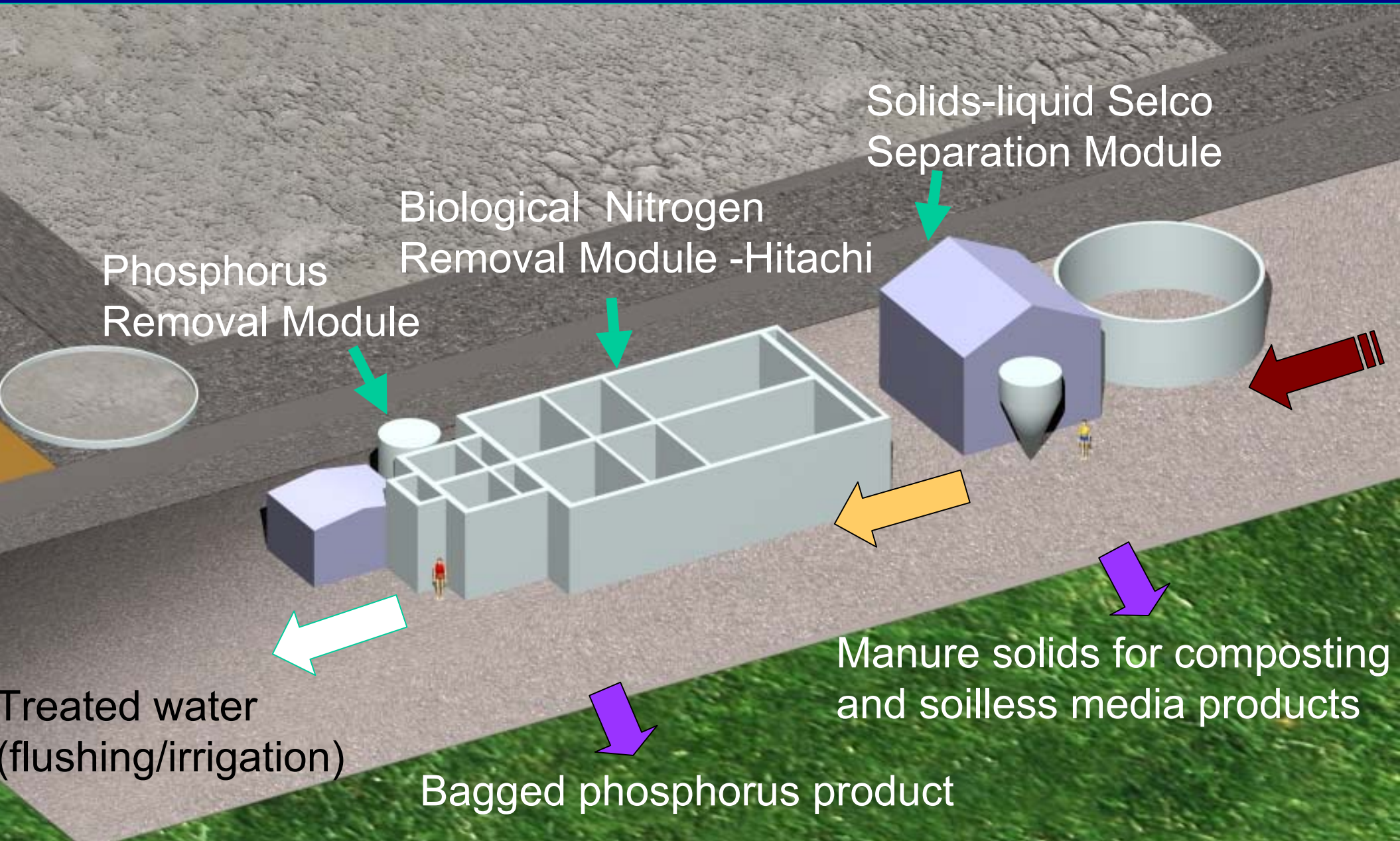
P₂O₅ value = \$0.25/lb

interest rate = 8%

	Annual cost
Reactor module	\$1,694
Dewatering and bagging equipment	\$3,341
Chemical cost	\$472
Dewatering and bagging operating cost	\$1,488
Sale of fertilizer P product 11,800 lb P ₂ O ₅	-\$2,949
Cost per finished pig	\$0.33

Smithfield Project: Waste treatment system without lagoon

Three modules: PAM solids separation, N removal, P removal.



Economic Feasibility of Total System

\$ per finished pig

WASTEWATER TREATMENT COST

Solids Separation	3.23
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Nitrogen Removal	2.33
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Phosphorus Removal	0.33
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Total	5.89
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REVENUES FROM MANURE PRODUCTS	6.83
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OVERALL COST	-0.94
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Finishing operation with 4360 pigs in NC

